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TWO PLANS

FOR

Protecting The City of Petaluma

FROM

OVERFLOW WATER

AND FOR

Improving Navigation of Petaluma Creek

J. R. PRICE, C. E., Chief Engineer,

M. A. NURSE, Assistant Engineer.

MAR 23 1896

STATE OF CALIFORNIA
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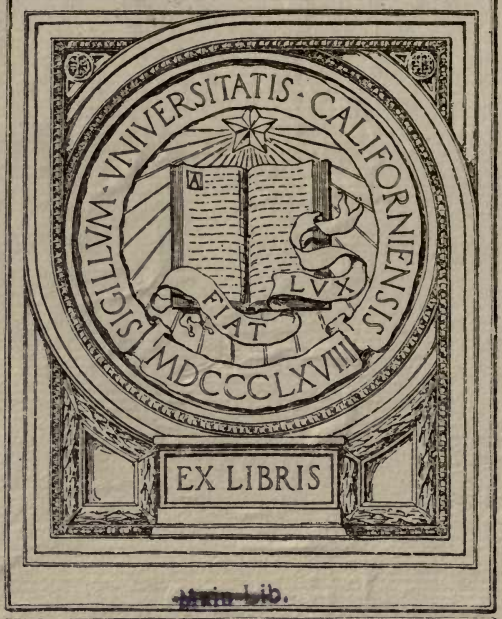

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TWO PLANS

FOR

PROTECTING THE CITY OF PETALUMA

FROM

OVERFLOW WATER,

AND FOR

IMPROVING NAVIGATION OF PETALUMA CREEK.

BY

J. R. PRICE, C. E., CHIEF ENGINEER, and
M. A. NURSE, ASSISTANT ENGINEER,
Of the California Department of Public Works.

[BEING A SURVEY CARRIED ON UNDER AUTHORITY OF COMMISSIONER OF PUBLIC WORKS.]

SACRAMENTO:
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DEPARTMENT OF PUBLIC WORKS.

ED. E. LEAKE ..... Commissioner.

J. R. PRICE ..... Engineer-in-Chief.

M. A. NURSE ..... Assistant Engineer.

JUDSON BRUSIE, Secretary and Attorney.

LETTER OF TRANSMITTAL.

SACRAMENTO, CAL., December 14, 1895.

HON. JAMES H. BUDD, *Governor of the State of California:*

DEAR SIR: I submit herewith a report of the Chief Engineer, and his Assistant, of the office of the Commissioner of Public Works—two plans for protecting the City of Petaluma and adjacent country from the overflow water of Petaluma Creek and certain tributaries, and for improving navigation, by correcting the channel of said creek.

The preliminary examination and the subsequent surveys were made in compliance with your request, based upon an application received from the City Trustees of the City of Petaluma.

After a careful examination of the topography of the country affected by the flood-waters, the Commissioner and Engineers concluded that it would be possible to devise a plan for practical and substantial relief at a reasonable cost.

At a subsequent public meeting, attended by all the prominent business men and property owners of Petaluma, reliable information was furnished to the representatives of this office which emphasized the necessity for the perfection and submission of such plan, or plans, with as little delay as possible, and the Engineers were directed to proceed with the work.

Their report is very elaborate, and treats of every aspect of the problem in minute detail. It is cogent in statement, systematic in arrangement, and explicit in the solutions offered. The calculations are made with arithmetical precision, and the estimates are based upon conditions with which the Engineers are thoroughly familiar. The maps and drawings accompanying the report were prepared with great care, and are absolutely accurate.

No plan can possibly succeed that does not involve the correction of the channel of Petaluma Creek. Such correction will vastly improve navigation, and should be promoted by Government aid. If the report meets with your indorsement and approval, it is urged that you forward the same to the California Senators and Representatives in Congress, with such further recommendations as you may deem proper.

In order to show the importance of maintaining the navigability of Petaluma Creek, I submit herewith some statistics compiled from information furnished by owners of vessels, and by the leading merchants, manufacturers, and business men, concerning the traffic and the amount and value of shipments on Petaluma Creek for the year ending May 31st, 1894.

242667

STATISTICS.

Articles.	Tons.		Value.
Barley	4,050		$60,750
Bran and mill feed	6,000		108,000
Brick	500		1,800
Butter	5,300		250,000
Coal	1,845		16,605
Corn	3,650		73,000
Cheese	132		52,800
Cement	1,100		16,500
Flour	4,900		171,500
Fruits—green, 2,200; dried, 245; canned, 50. Total,	2,495		125,000
Gasoline	10		625
Hay	10,000		120,000
Hops	65		19,500
Hides	90		7,200
Ice	75		1,500
Incubators and breeders	300		90,000
Iron and steel	285		11,000
Lumber	6,000		158,000
Lumber (hardwood)	200		2,000
Laths	300		3,564
Lime	670		10,050
Leather	100		50,000
Machinery	75		15,000
Merchandise, general	16,500		8,250,000
Oats	1,900		38,000
Oil cake	140		4,900
Pelts	18		1,440
Potatoes	7,800		93,600
Pickets	65		800
Plaster	18		414
Pipe, iron	185		18,500
Paving blocks	1,290		8,600
Shingles	550		6,600
Shakes	200		2,400
Silk—raw, 24; manufactured, 16; dye stuff, etc., 48. Total	88		379,200
Shells	500		2,600
Solder	5		1,600
Salt	1,600		17,600
Stone and gravel	2,000		2,000
Tallow	50		51,000
Tin and tin cans	50		8,000
Wheat	17,260		345,200
Wool and woolen goods	1,540		308,000
Eggs	1,021,560	dozen	204,312
Wood	625	cords	3,125
Tan bark	50	cords	700
Wine	194,000	gallons	19,400
Brandy	14,000	gallons	21,000
Vehicles	600		60,000
Mowers and reapers	140		10,500
Horses and cattle	4,754		190,160
Colts and calves	520		5,100
Sheep and hogs	4,600		23,000
Passengers	12,126	(fare paid)	6,063
Total estimated value			$11,438,145

Petaluma Creek insures for the farmers and producers cheap transportation, and its importance is so apparent that any argument on that line is wholly unnecessary.

The Government has made a small appropriation for the improvement of the channel, but the plans upon which this improvement is to be made will not afford relief to Petaluma; neither will they effect permanent improvement of navigation. At best, the money so expended can afford only temporary relief.

A proper alignment of the channel should be sought immediately, and property owners should concede to the Government the right of way in order that the corrections may be made. Citizens of Petaluma, if they desire to maintain and keep open a cheap route of transportation, should obtain these rights of way, and should insist that all future improvements shall be of a character that will meet the demands of the commerce of the future, the importance of which cannot be overestimated.

The correction of the alignment of Petaluma Creek, as suggested by the report of the Engineers, is an improvement that should be made from the head of navigation to the deep waters of San Pablo Bay.

The importance of the commercial interests of Sonoma County demand that they shall be fostered and protected and cheap transportation insured by the maintenance of an open, well-aligned deep waterway.

These advantages, linked with the natural resources of a fertile county, will result in a high development and an immeasurable prosperity to the people.

It is not an inspiring sight to see light-draught passenger and freight steamers waiting for the return of the tide in order that they may pass in safety the sand bars of a navigable stream.

Petaluma Creek is entirely within the confines of tidal influences, so far as navigation is concerned, and, as before stated, the commercial interests of that portion of the State are of sufficient importance to warrant the rectification of the alignment of the creek, and its excavation to a depth sufficient for a navigable, low tide waterway.

Presuming that the commerce of Sonoma County will keep pace with the increase in population, it should not be a difficult proposition to convince Congress of the necessity and urgency for Government aid in promoting improvement and rectification of Petaluma Creek on a plan similar to the one suggested in the report of the Engineers for the care of flood-waters.

Respectfully submitted.

ED. E. LEAKE,
Commissioner of Public Works.

REPORT.

To HON. ED. E. LEAKE, *Commissioner of Public Works, State of California:*

The matter of survey and recommendation of plan for the care of flood-waters in the town of Petaluma and vicinity, in Sonoma County, California, having been duly referred to us for investigation, we beg to submit the following report:

The survey and field work was commenced in the early part of July of this year, and continued without cessation until its completion in the early part of August.

The problem involved in the case resolves itself into:

First—The care of flood-waters of Petaluma Creek, coming from a drainage area of eighty (80) square miles of territory.

Second—The care of flood-waters arising from the drainage area of Reservoir, Edwards, and Thompson Creeks, embracing 1,407 acres of drainage area.

THE CARE OF FLOOD-WATERS OF PETALUMA CREEK.

The City of Petaluma is located at the head of navigation on Petaluma Creek, which creek, having its source arising from many small creeks in the Coast Range Mountains of Sonoma County, flows in a southeasterly course to the Bay of San Pablo.

Petaluma City is, therefore, the principal shipping point for all merchandise either to or from San Francisco, and the commercial center of a vast fertile country along the line of Petaluma Creek, as well as of the exceedingly prosperous Russian River Valley.

Petaluma Creek enters the city limits of the City of Petaluma on the northern boundary line of said city, and winding along a snake-like course passes on to tide-water in the eastern portion of the corporate limits thereof.

An inspection of the maps presented with this report will set forth a clear conception of the situation.

From the northern boundary line of the city to the intersection of the creek with the S. F. & N. P. R. R. the lands flooded by the excessive flow of storm-waters are of considerable acreage, but being for the most part unoccupied by buildings, and used for agricultural purposes, we do not recommend a plan for the reclamation of these lands, but respectfully submit that should a reclamation be desired, it can be accom-

plished by a simple system of embankments with proper elevations and grades.

From the crossing of the S. F. & N. P. R. R. of Petaluma Creek to the east boundary line of the city, the creek has a very tortuous course, resulting in the retardation of the flow of waters, and causing a flooding of a considerable portion of the City of Petaluma during flood seasons.

Washington Street, which is the principal avenue used for traffic between the S. F. & N. P. R. R. depot and Main Street, has been graded and laid in basalt blocks, which grading has caused a closing of the natural course of flood-water channel, forcing the water to pass under Washington Street bridge, or over this graded street in its lowest elevations.

The waterway under Washington Street bridge is inadequate to the task of conducting the flood-waters, and hence at extreme flood-periods the water is gorged, until it runs over said street to the depth of two and one half feet. This condition of things necessarily floods the lands above Washington Street at times, endangering valuable property interests.

So also does the marked incapacity of the stream appear, from Washington Street to the east boundary of the city, by frequent overflow during flood-periods. You will observe, by an examination of the maps herewith presented, that some of the most valuable property of the city is simply at the mercy of the waters, and a relief only comes by a subsidence of floods.

It is to this condition that we propose a remedy.

From careful surveys and all reliable data that we can obtain, Petaluma Creek at its highest flood-periods discharges not to exceed 3,000 cubic feet of water per second.

From the same data, we find that the greatest flow of water under Washington Street bridge at flood-periods could not be more than 2,000 cubic feet per second, when at the same time 1,000 cubic feet per second must have been running over Washington Street between the bridge and the S. F. & N. P. R. R. depot. Therefore, no plan which we can suggest would safely dispose of the waters through the present waterway passing under Washington Street bridge.

Two methods have suggested themselves to us for a drainage system for the flood-waters of Petaluma Creek.

It seems to be the verdict of all who have made an examination of the situation, that the water, if possible, should be taken into a canal at the crossing of the S. F. & N. P. R. R., and conducted thence down Bayles Street to its intersection with Petaluma Creek, and thence levee the creek to the eastern boundary of the city.

With a view to test this theory, we made proper surveys, taking the necessary elevations and locating property lines and improvements to determine the probable cost and feasibility of the plan.

It is found that the property owners could give sufficient right of way, together with the street, to enable the construction of a canal one hundred (100) feet in width on the grade line along this route. But a canal one hundred (100) feet in width, with the grade that can here be obtained, running water five feet in depth, will not safely conduct the flood-waters of Petaluma Creek. Indeed, it is safe to say that such a canal, with all the fall that can be given, will not discharge more than fifteen hundred (1,500) cubic feet per second, which we perceive is only one half of the discharge of Petaluma Creek. But it will be asked why not make it deeper or wider?

We observe that it should not be deeper or wider, because this would involve the increase of the elevation of the embankments to such a height as not only to be dangerous, but extremely inconvenient to adjoining property.

It cannot be made wider on this route without great damage to property and excessive cost for right of way. If the embankments were increased in elevation sufficient to make a canal one hundred (100) feet on base or grade line, carrying all the flood-waters of the Petaluma Creek, then would we be compelled to begin our canal much farther up the creek, or build a dam at the railroad crossing, which is entirely impracticable.

Therefore, we regard it as an impossibility to conduct all the flood-waters of Petaluma Creek through a canal on Bayles Street with the above dimensions.

In an examination of the causes of overflow, we find that a very large proportion of the flood-waters of Petaluma Creek come from the drainage area of a creek running down Washington Street produced to what is known as "Schoolhouse Corner," a point one mile and a half northerly from Washington Street bridge; also from a creek known as "Lynch Creek," running nearly parallel with Washington Street Creek, and both joining Petaluma Creek near the northerly boundary of the town of Petaluma.

These creeks are drawn and delineated on a map herewith presented.

Washington Creek, as it is named on said map, will discharge at flood-periods about 650 cubic feet of water per second.

Lynch Creek will discharge not to exceed 1,000 cubic feet of water per second during flood-periods.

Therefore, these two creeks produce at the head of overflow at least one half of the volume of flood-waters required to be cared for.

We have made a preliminary survey, and find that these two creeks can be diverted so as to discharge their waters onto the salt marsh east of the town of Petaluma without entering the incorporated limits of said town.

For this reason we will embody in this report the probable cost of construction of such a scheme, exclusive of cost of right of way.

Washington Street Creek and Lynch Creek discharge a large percentage of the sediment to be cared for in Petaluma Creek, by virtue of their close proximity to the head of overflow, and we would suggest, that should their waters be caused to take the course above referred to, the sediment in Petaluma Creek will be exceedingly small, and will be easily cared for by the velocity of the water in Petaluma Creek.

Copeland Creek, one of the branches of the Russian River system, has its origin in the Coast Range Mountains, northwest of the town of Petaluma some eight or ten miles, and, flowing westerly down the Coast Range slope to the Russian River Valley, discharges its waters onto the divide or watershed separating the waters of Petaluma Creek from Russian River.

At times of greatest rainfall, Copeland Creek becomes gorged to such an extent that a portion of its waters separate from the main channel, and instead of flowing into Russian River take a southeasterly course and join the waters of Petaluma Creek.

This can readily be prevented by a very moderate expenditure at the point of separation of the waters of Copeland Creek, and we earnestly recommend that it should be done.

It is our opinion that five hundred dollars ($500) properly expended would accomplish the purpose.

Having once disposed of the flood-waters of Washington, Lynch, and Copeland Creeks, other than through the channel of Petaluma Creek, we feel secure in recommending a canal on the line of Bayles Street, as shown on maps herewith presented, with a width of base of one hundred (100) feet and with proper slopes, and under no other circumstances.

We have therefore prepared profiles and made estimates of the cost of a canal based upon the above conditions, a statement of which will appear hereafter in this report, which we will designate as the *Bayles Street System.*

In view of the fact that a great many obstacles might confront the Bayles Street scheme, we have made a critical examination of the case in order that we might find some other line of relief—one that would safely care for all of the flood-waters of Petaluma Creek without resorting to canals or construction works outside of the corporate limits of the town.

We find that a canal of proper dimensions can be constructed on a line laid down on the maps herewith presented, and marked and designated by the red lines on said maps.

This canal will have for its initial point the crossing of the S. F. & N. P. R. R. with Petaluma Creek and run thence across the flooded portion of the town to a point about 150 feet east of the easterly side of Wash-

ington Street bridge crossing Petaluma Creek, and thence gently curving to the left, making an easy entrance to Petaluma Creek, as shown on maps herewith presented.

It will require a canal 125 feet in width on the base or grade line, with side slopes three horizontal to one vertical, and running a depth of five (5) feet of water, with a fall of .07 of a foot to 100 feet, to discharge 3,000 cubic feet per second, which is the maximum flow of Petaluma Creek.

We have made estimates of probable cost of such a canal on the lines designated in red on said maps, a comprehensive statement of which will be hereafter given.

You will observe by an examination of the location of buildings and other improvements as shown on the maps, that it is somewhat difficult to lay down on the ground a canal that will cause the minimum damage to property interests, and at the same time obtain a good waterway.

With these paramount principles in view, we have sought to make a location which would dispose of the flood-waters, and at the same time cause the least damage to property.

THE BAYLES STREET SYSTEM.

The main waterway or canal in the Bayles Street system will have for its initial point the crossing of the S. F. & N. P. R. R. with Petaluma Creek. Thence curving gently to the left, as indicated on the map in blue lines, until the center line becomes tangent to a line on Bayles Street, and follow the same, as shown on map herewith presented.

The width of the canal on base or grade line is established at 100 feet. Side slopes, except where concrete retaining walls are required, shall be three horizontal to one vertical. Crown of embankments 8 feet in width, and of a uniform elevation of 2 feet above the surface of water in canal. Embankments to have not less than three horizontal to one vertical side slope. The uniform grade of the canal shall be .007 per running foot, descending from the initial point to its intersection with the center line of G Street on Petaluma Creek. The elevation of grade line at the initial point being 11.38.

All embankments on the line of Petaluma Creek must be so constructed as to conform to this grade.

No filling in will be made to obstruct navigation; on the contrary, a complete system of embankments on either side of the creek must be constructed to the head of navigation, so as to prevent any possible damage from overflow. An embankment will be made at Washington Street crossing of Petaluma Creek, to prevent the flooding of lands north and west of Washington Street.

From the point where Bayles Street now enters Petaluma Creek, to a point 100 feet northerly from the north line of Washington Street, the

canal will require concrete retaining walls on either side thereof, whose upper surface shall conform to the grade of the crown of the embankments of said canal, and of sufficient depth to rest upon the hardpan bottom of the canal.

One pile bridge at the intersection of the canal and Washington Street must be constructed for the accommodation of traffic.

The canal must be protected from cutting of embankments at the initial point by a systematic riprap of rock work.

From the intersection of Bayles Street with Petaluma Creek to the center of G Street, each bank of said creek must be raised to a uniform grade, as heretofore referred to, by excavating earth from the present channel of the creek and placing the same on either embankment.

It is here assumed that this earth work on Petaluma Creek will be constructed by dredging, while all other earth work must be constructed and excavated with horse-scrapers.

We therefore have the following statement of possible

Cost of Construction of the "Bayles Street System."

(Exclusive of cost of right of way.)

Improvement of Copeland Creek		$500 00
Diversion of Washington and Lynch Creeks—34,517 cubic yards earth work, at 9 cents	$3,106 53	
180 feet bridging	900 00	
		4,006 53
Bayles Street Canal—		
16,500 cubic yards excavation, at 12 cents	$1,980 00	
10,843 cubic yards embankment, at 9 cents	975 87	
22,500 cubic feet concrete walls	5,625 00	
100 feet pile bridge, 40 feet wide	1,000 00	
4,000 cubic yards fill for Washington Street, at 25 cents	1,000 00	
Superintending and engineering	1,000 00	
		11,580 87
Total cost of construction		$16,087 40

Cost of Canal System within Corporate Limits.

(Exclusive of right of way.)

23,430 cubic yards excavation, at 12 cents	$2,811 60
21,461 cubic yards embankment, at 10 cents	2,146 10
15,099 cubic yards embankment on creek, at 9 cents	1,358 91
13,000 cubic feet concrete at Washington Street crossing	3,333 33
132 feet pile bridge, 40 feet wide	1,320 00
4,000 cubic yards earth filling at Washington Street crossing	1,000 00
Superintending and engineering	1,000 00
Total cost of construction	$12,969 94

In the estimate of the cost of construction of the last above-named canal, it will be observed that we have included an item of $3,333 33 for concrete work where said canal crosses Washington Street. It may be found advisable to increase the bridge work and exclude the concrete work. In that event the above estimate could be reduced in the sum of

$3,000, making the total cost $9,969 94, on the line as laid down in red on the maps herewith presented.

We would recommend the work on Copeland Creek to be done, no matter which system be adopted. It is possible that by neglect, the whole of the flood-waters of Copeland Creek may change their course and join Petaluma Creek in place of taking their proper channel into Russian River. Should such a condition be permitted to obtain, the danger to destruction of property in the town of Petaluma will be great and the consequences extremely disastrous.

We therefore earnestly urge upon the property owners of the town of Petaluma to leave no time pass, nor winter season come, before the proper remedy is applied to this evil.

It will not be out of place for us to remark, before dismissing this subject—the Bayles Street System and other system—that the question of right of way will, in all probability, cut a very large figure in the determination of the location of any line of improvements.

We believe, however, that a canal located as shown by the parallel red lines on the maps herewith presented, within the corporate limits of the city, will more readily satisfy the condition for least cost for construction and for right of way, and at the same time perform all the work required to give a speedy and proper relief.

It will be observed that the grade of the embankments being two (2) feet above the grade of the surface of the proposed flood-waters, the canal can be relied upon to safely conduct more than 3,000 cubic feet of water per second.

The embankments must, however, be maintained at their original grade, and the canal perfectly clear of all obstructions.

THE CARE OF WATERS OF RESERVOIR, EDWARDS, AND THOMPSON CREEKS.

Reservoir, Edwards, and Thompson Creeks are three small creeks having their watersheds south of the City of Petaluma, and, flowing in a northerly direction, deliver their waters into the residence portion of said city. Coming as they do from an abrupt, hilly watershed, they rush from the cañons that confine them, with torrential velocity, to a gentle sloping watershed, where they must necessarily spread beyond natural confines in flood-periods.

Indeed, the sedimentary deposit from each creek is sufficient to fill the old channels on the gentler slopes, so as to render their capacity almost useless.

From data obtained from the City Clerk's office of the City of Petaluma, we learn that Reservoir Creek has a drainage area above D, E, F, and G Streets of 87 acres; Edwards Creek, 417 acres; Thompson Creek, 903 acres; making 1,407 acres of drainage land for all three of these creeks.

It seems, therefore, that it is but a small problem to solve; yet when we consider the conditions that here present themselves, the problem grows in importance, until it becomes a very serious question to the City of Petaluma.

Entering the corporate limits of this city at an elevation of 50 feet or more above low tide, and having a distance of not more than 4,000 feet to run to tide water, the consequences can readily be imagined, when 600 or 700 cubic feet of water per second is dashed upon the most thickly populated portion of the city.

Sewers constructed for ordinary city drainage purposes become gorged beyond their capacity, and with hydraulic pressure throw off the manhole covers, producing an exit instead of an entrance for storm-waters.

Bewildered in the maze of circumstances, the city authorities have caused a portion of F Street to be laid in basalt blocks, with a hope of conducting the surplus waters down this street. The street is of the usual form, having of necessity but a small water capacity, perhaps a sufficient capacity to conduct the waters of the smallest of these creeks to tide water.

It seems that the error has been committed here, that is so often met with in the State, of underestimating the flow of storm-waters. Ordinary rains or ordinary floods are not what we should aim to control, but the extreme flood-periods are those that cause the greatest destruction to property.

Therefore, the Engineer, if he desires to cure the disease, must apply the proper remedy, which in this case can only be a waterway of ample capacity to control the flood-waters of any storm that it is reasonable to expect.

Temporary relief may be obtained by individual property owners by widening or deepening the old channel of Thompson Creek, but certain it is that it is only temporary.

The earthen channel, conducting water running at the rate of 9 or 10 feet per second, or 6 or 7 miles per hour, is at most but a temporary concern, for, by the nature of things, the tenacity of the earth is totally unable to withstand the force of the impact produced by the flowing waters; the result is, shoals and bars form, cutting and caving of banks predominate, producing a winding or tortuous stream, retarding the flow of the waters, and hastening the destruction of the original channel.

The citizens of Petaluma must therefore bring themselves to a realization of the conditions that here present themselves. Temporary work should be discouraged. It is a useless expenditure of money wherein one property owner is only relieved to the detriment of some fellow property owner, and, in the end, there will have been expended a sum of money sufficient to have constructed a systematic relief, and yet no relief has been accomplished.

We have carefully examined the data as to rainfall in the vicinity of Petaluma, and find that in January and February of the present year the greatest rainfall was 1.87 inches for twenty-four hours.

This quantity of water uniformly distributed over an area of 1,407 acres of land would be equivalent to 110 cubic feet per second. This would require a very small drain-pipe to discharge it, were this the actual amount of water to be controlled. But under any presumption, a portion of this water would be absorbed by the lands and a portion disappear by evaporation.

Now let us see what was the probable greatest quantity of water presented at any one time from this drainage area. Reservoir Creek discharges more than enough water to fill the pipe at the crossing of Sunny Slope Avenue, which pipe under the most favorable circumstances could not discharge more than 50 cubic feet of water per second and not less than 40 cubic feet.

Edwards Creek crosses under Sunny Slope Avenue through a culvert or drain-pipe, circular in form and having a capacity, with a head of 8 feet, of 285 cubic feet per second.

Thompson Creek, at a point near Eighth Street, discharges its waters through a channel whose capacity is estimated by us at 600 cubic feet per second.

All indications of high-water marks at the various points above named lead to the inevitable conclusion that these figures and estimates of flow of water are not in excess of the actual flow of water from these various sources during flood-periods.

We therefore conclude that the record of rainfall is no gauge of the capacity of an aqueduct required to care for the waters of the creeks.

The conclusion must therefore be that a heavy rainfall occurs in a very short period of time, and will require a canal or storm sewer of ample capacity to meet these sudden floods.

Believing, therefore, that we have, by facts stated above, arrived at a safe estimate of the flow of the water from these creeks during extreme storm-periods, we conclude that a drainage system must be constructed that will satisfy the following conditions:

Discharge of Reservoir Creek	50 cubic feet.
Discharge of Edwards Creek	300 cubic feet.
Discharge of Thompson Creek	600 cubic feet.
Total discharge	950 cubic feet.

It may be possible that the estimate above given for Thompson Creek is somewhat in excess of the actual discharge of that stream, but in view of the fact that the drainage system, wherever it may be located, will concentrate all of the waters of these three creeks into one channel, together with the drainage of the watershed adjoining its route, we deem

it advisable to calculate the capacity of a storm sewer which will discharge the amount of water above stated.

As already stated in this report, the velocity of water in the creeks above named is at least 9 feet per second, and in many portions of the channel it reaches a much greater velocity.

From the nature of the topography of the country over which the water passes, it will be found impossible, within any degree of reasonable distance, to conduct these waters to tide water through an earthen channel with a grade or fall sufficiently gentle to prevent cutting or erosion of any new channel that could be constructed.

If an earthen channel or canal should be constructed on any line within the scope of our survey, the result would be a cutting and destruction of the channel alignment, and finally the complete nullification of the objects desired to be obtained.

We therefore conclude that any system of relief that may be suggested with a view to permanency should be upon a plan which will at all times maintain the functions upon which the system is based.

This will require either rock work, brick work, or wood work for the construction of any system which should be adopted.

It appears to us that the cheapest and most available material at hand will be in the nature of concrete or cement rock work. It is our opinion that what is known as dry rock work will not satisfy the conditions here presented, being subject to displacement by the force of the current, unless extremely well laid.

Therefore, we will recommend that the storm sewer here proposed to be constructed be laid in concrete work or stone thoroughly laid in cement mortar, except where otherwise designated.

We will present for the consideration of the citizens of Petaluma two systems of relief, believing that in so doing we will illustrate thoroughly the problem under discussion.

The first system of relief that we shall discuss will be a succession of open canals or storm sewers, beginning on Sunny Slope Avenue at its intersection with D Street, and running thence along the north side of Sunny Slope Avenue 1,850 feet more or less, and thence curving gently to the left and delivering the waters of Reservoir and Edwards Creeks into Thompson Creek, as shown by red lines on maps herewith presented. Thence conducting the waters of all of these creeks through a canal on line as here shown on map in red, to tide water, at a point on Petaluma Creek 250 feet west of the easterly boundary line of the town of Petaluma.

The grade line of the canal is shown upon profile herewith presented, which refers at all times to the same datum plane used in the survey of relief canal for flood-waters of Petaluma Creek, heretofore set forth in this report.

We find that the waters of Reservoir Creek can be delivered into Edwards Creek, on Sunny Slope Avenue, with a grade of 4 feet in 540 feet, which would require a pipe 3½ feet in diameter. The cost of a pipe with 3½ feet bore will be in excess of five ($5) dollars per running foot, at the same time exceedingly liable to dam up with obstructions; therefore, we will recommend an open concrete sewer for this portion of the work.

We here recommend an open storm sewer whose dimensions will be shown on profile, and cross-section adjusted to the various grades.

The waters of Reservoir Creek will be introduced into the canal or storm sewer at Edwards Creek, which canal will conduct the combined waters of Reservoir and Edwards Creeks into Thompson Creek, and the Thompson Creek storm sewer is calculated to deliver the combined waters of the three creeks into Petaluma Creek, at the point above named, under all circumstances and without damage to the City of Petaluma.

In order that this system of storm sewers shall perform all the work assigned to them, the interior surface must be of concrete or material that will offer no greater resistance to the flow of water than is expected from a concrete surface.

Stone work faced with a cement mortar will serve the same purpose. It is upon this assumption, and this alone, that we have been able to reduce the waterway to its minimum capacity.

If any change of grade or dimension of storm sewer should be found advisable in construction, a strict adherence to rules of calculating capacity for this character of canal must be observed.

As the dimensions of waterway and concrete will be found in cross-section on profile herewith presented, we regard it unnecessary to further describe the plan of works here recommended, except to say that wherever deemed advisable the canal can be covered with plank flooring to obviate danger and remedy inconvenience of crossing.

We have, therefore, the following estimate of concrete work, excavation, and earth work, and probable cost of construction:

From Reservoir to Edwards Creek, 7,290 cubic feet concrete	$1,458 00
From Edwards to Thompson Creek, 47,100 cubic feet concrete	9,420 00
From Thompson Creek to Petaluma, 103,540 cubic feet concrete	20,708 00
Excavation and embankment, 14,860 cubic yards, at 15 cents	2,229 00
Lumber for bridges, 22,000 feet	550 00
Total cost of Sunny Slope system	$34,365 00

The second system of relief that we shall propose for the care of flood-waters of Reservoir, Edwards, and Thompson Creeks will be constructed in such a manner as to concentrate all of the waters of these creeks on the line of Eighth Street and thence to tide water.

The waters of Reservoir and Edwards Creeks will be permitted to flow

in their present channel to a point about 200 feet south of the south line of Eighth Street, at which point they will be conducted into an open concrete storm sewer to G Street, there to join the waters of Thompson Creek, as shown on map herewith presented.

The waters of Thompson Creek will be permitted to flow through their present channel to a point near the south line of Eighth Street, where they will be introduced into a concrete storm sewer, which will conduct them to the east line of G Street, and thence along the east line of G Street to tide water in Petaluma Creek.

The greatest width of waterway in storm sewer at the top of surface thereof will be 14½ feet, which, together with concrete or rock work, will require 16½ feet in width for construction.

To avoid expensive covering, we would locate the storm sewer on the east side of the street, immediately under the sidewalk, and cover the same, making the covering serve the purpose of a sidewalk.

The street crossings must be covered with bridge work. For this purpose we recommend four (4) inch plank resting on 3 x 14 stringers, resting on the top of the concrete walls of the same sewer. All other portions of the sewer to be covered with two (2) inch plank, thoroughly laid and spiked to longitudinal pieces.

The waters of Edwards and Reservoir Creeks will be introduced into Thompson Creek by a storm sewer 4 feet on base of waterway, 6 feet wide on surface, and running, during extreme floods, water 5 feet in depth.

We have, therefore, as an estimate of the probable cost of construction of G Street system, the following:

99,375 cubic feet concrete or rock work, at 20 cents	$19,875 00
10,121 cubic yards excavation, at 15 cents	1,518 15
102,270 feet lumber, at $25 per M	2,556 75
Total probable cost	$23,949 90

The above estimate for price of lumber is presumed to cover all expense of delivering and placing the same in the flooring or bridges.

No estimate is here included for superintending and engineering, but the figures are believed to be sufficiently great to cover all possible expense, and, if judiciously managed, the work may cost much less.

It must be ever borne in mind that the storm sewer here recommended is intended for storm-waters, and storm-waters alone. No sewage must be permitted to enter it. There is no means provided for flushing it, and it would become a filthy deposit, without hope of relief, should it be used for sewage purposes.

All storm-waters may be introduced into it from street grading without fear of injury, but the city must be provided with other sources of discharge for sewage matter. Pipes and drains from houses must be led

into closed sewers, which will conduct the disease-breeding matter to a safe depository.

By construction of this system of storm sewers the city will be enabled to lay sewer pipes of minimum capacity and at a very slight cost.

We believe that a system such as here recommended will at all times maintain a clean, unobstructed channel, located so as to render no inconvenience.

In conclusion, we regard it proper to remark that the cost of material and labor upon which our estimates are based is figured as close to our knowledge of the cost of this class of work as the circumstances will permit.

Should the plans herein recommended be adopted, the work and material should be supplied under contract, when it may be ascertained that the works can be constructed at a less cost than herein estimated.

Trusting that the plans and information presented in this report will serve to guide the citizens of Petaluma to a permanent relief from the effects of floods, we submit the same.

Very respectfully,

J. R. PRICE,
Chief Engineer.
M. A. NURSE,
Assistant.

SACRAMENTO, November 30, 1895.

OFFICE OF THE CITY CLERK,
PETALUMA, CAL., March 26, 1895.

To HIS EXCELLENCY JAMES H. BUDD, *Governor of the State of California:*

SIR: I am instructed by the Board of Trustees of the City of Petaluma, to forward for your consideration the accompanying resolution, and in explanation thereof, to say that the authority for directing the survey therein requested to be made is conferred upon you by an Act of the Legislature. (See Statutes of California, 1893, page 345.)

It is not the desire nor intention of this city to ask the State to undertake the work that may be recommended to be done by the Commissioner of Public Works; but to get from said officer a comprehensive plan for taking care of the flood-waters that annoy us and damage the property of our citizens.

Trusting you will give this subject-matter your earnest and earliest consideration, I am, sir,

Respectfully yours,

THOMAS MACLAY,
City Clerk.

RESOLUTION.

By President Drees, seconded by Mr. O'Reilly:

Resolved, That the Governor of the State of California be and he is hereby respectfully requested to direct the Commissioner of Public Works to cause an examination and survey to be made in the City of Petaluma, with the object of devising a scheme looking to the proper work to be performed for the stopping of damage to property in this city by reason of the overflow of the waters of Petaluma River and other streams tributary thereto.

Adopted.

EXECUTIVE DEPARTMENT,
STATE OF CALIFORNIA.

Respectfully referred to the Commissioner of Public Works, with the request that he look into the matter.

JAMES H. BUDD.

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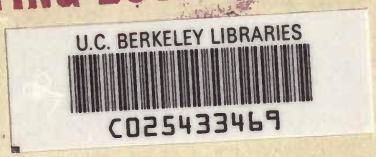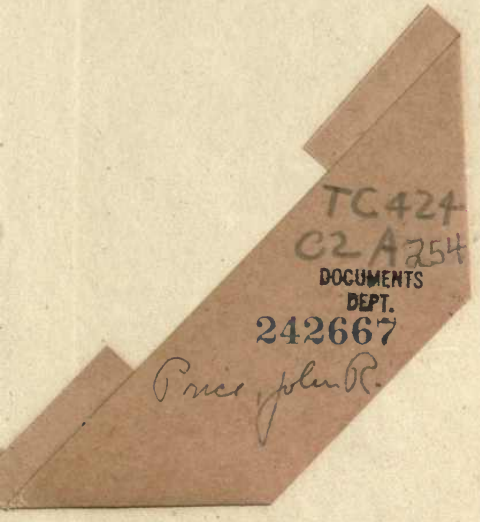
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